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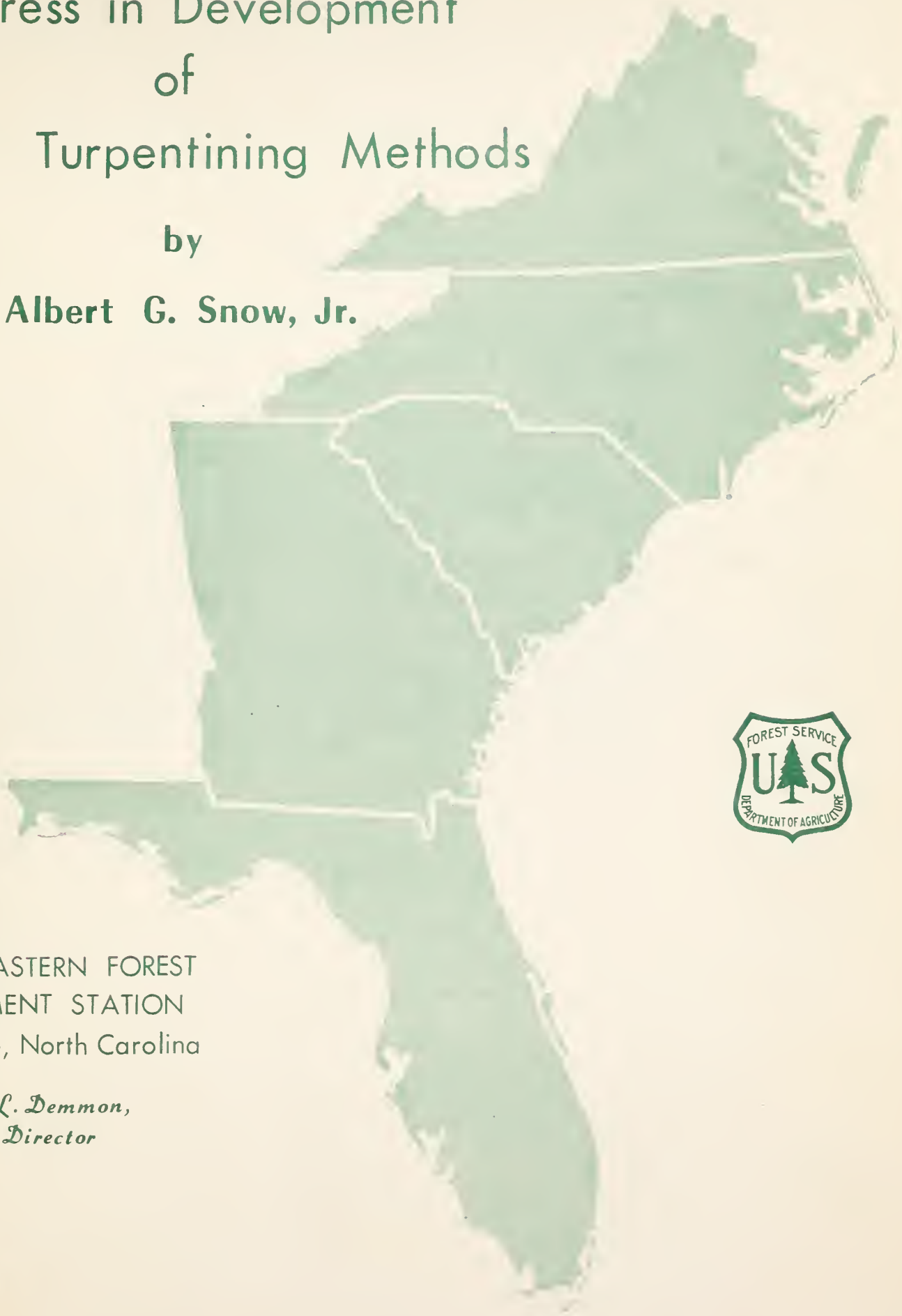
Progress in Development of Efficient Turpentining Methods

by

Albert G. Snow, Jr.



SOUTHEASTERN FOREST
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PROGRESS IN DEVELOPMENT OF EFFICIENT TURPENTINING METHODS

By

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INTRODUCTION

Considerable progress has been made during the past 5 years in the development of more efficient turpentining methods for use on slash and longleaf pines (18,19,20,21,22,23,33).1/ The backbone of this progress rests in the use of bark chipping, with sulfuric acid treatment on a 2-week schedule. Original work on the use of different chipping systems and treatments with many different chemicals was reported in 1944 (28). This initial summary publication contains a comprehensive digest of all the early work and serves as a progress report on the studies completed before then. A 1948 publication (31) covers the next 4 years of progress in studies of many different turpentine systems, and contains practical recommendations for the producer, based on experimental data collected through 1947.

Since 1947 all of these earlier studies have been completed. In addition, other experiments have furnished further information on more efficient turpentining systems. The present paper will cover the results of all experiments conducted since 1947, and draw conclusions based on the consolidated information gained during the past 10 years of concentrated research effort.

PROCEDURES

The same general procedures described in previous reports (28,31) were followed in the experiments reported in this paper. We had found that the most efficient experimental approach to testing a number of different treatments in naval stores studies consisted of first arranging

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1/ Underlined numbers in parenthesis refer to literature cited.

the trees in groups of similar gum-yielding ability on the basis of yields obtained from an average of four calibration streaks. Then the experimental treatments were assigned at random to the trees within each yield group. Usually 10 to 15 trees were assigned each treatment.

Both slash and longleaf pine are economically important in the naval stores industry, and early studies demonstrated a different treatment response for each species, so duplicate experiments were started in most cases. All experiments were conducted in second-growth stands on the Osceola National Forest in northern Florida. Yields for slash pine were averaged for northeastern Florida. Yields from longleaf were somewhat low, since the longleaf sites available were not the best, though characteristic of many in this area.

Every two or three weeks, depending on the chipping frequency, gum yields were obtained by weighing to the nearest gram. These figures were later converted to gum yields in barrels (435 pounds of gum net) per crop of 10,000 faces. In this way both yield trends and total yields were obtained for individual trees and treatment groups.

The same miscellaneous details of experimental techniques used previously (28,31) were also incorporated in the studies reported in this paper. These include: face widths 1/3 circumference unless otherwise stated; tins fastened on with either tapered cut tacks or double-headed nails, in both virgin and elevating operations, according to modern recommendations (9,24,36); streaks chipped 1/2-inch deep and 1/2-inch high (1/2 x 1/2) with a No. 0 hack; bark chipping (BC) with a standard bark hack or bark puller; chemical solutions applied with the latest Evans or Nichols plastic squeeze sprayer.

FACTORS AFFECTING YIELD OF TREATED TREES

Virgin Cupping Methods

Original studies with deep chipping showed that gum yields were less from trees with gutters inserted with a broadaxe than from trees with the gutters tacked in shallow streaks (29). This decrease in yield with deep gutter insertions was attributed to interference with the movement of necessary food and water.

With increasing numbers of acid users who practice bark chipping, the question arose whether this same loss in gum yield with inserted gutters held true for the new method of chipping. In order to answer this question, the study reported in table 1 was started in 1950.

These results with bark chipping and acid treatment substantiate those of the previous work with untreated deep chipping (29). In addition, they strengthen materially our original concept that the depth of gutter insertion should be no deeper than the depth of chipping. This means that with bark chipping the tins must be fastened on the surface of the exposed wood or on smoothed bark to insure maximum yields.

Table 1.--Relative gum yields for two methods of hanging tins in virgin cupping

Type of installation	Gum yields per crop[1]		
	Slash	Longleaf	
	1951	1950	1951
	Bbls.	Bbls.	Bbls.
Broadaxe incision	256.6	147.6	129.2
Nailed on surface	286.9	198.7	175.4
LSD[2] bbls. per crop	42.4	39.5	42.9

1/ Average yield per crop (10,000 faces) for 32 weeks. All trees were bark chipped every 2 weeks and treated with 50-percent sulfuric acid.

2/ Least significant difference between treatments at 5-percent level. Same level used for all tables in this report.

The data of table 1 show that in slash pine a slight, but not significant increase in gum yield was obtained the first year from trees with gutters fastened on the surface of smoothed bark than from trees with gutters inserted with a broadaxe. In longleaf this increase averaged 35 percent for 2 years of work and was significant at the 5-percent level. This indicates the increased profits that may be obtained with a conservative gutter installation technique, since little or no extra cost is involved.

The availability of "spiral" gutters (24) greatly facilitated conservative virgin tin installation work. The exact method to use is described in detail in a previous publication (9). This latter article also cites the multiple advantages offered by the new method of virgin cupping with spiral gutters. These advantages are:

1. Virgin yields are increased over those obtained with the old axe-maul method.
2. Over-all production costs are reduced, as one cup, one set of double-headed nails, and one set of tins can be used for the life of the face.
3. The chipping of a "healing" or "lead" streak with this method is not necessary. Elimination of this job means more profit per barrel of gum for the producer.
4. Finally, a metal-free tree trunk permits the entire tree to be harvested for sawlogs, pulpwood, or poles, thus returning the greatest value for stumpage following turpentining.

Diameter

Several sources of information about the gum-yield level to be expected from trees of different diameter are available (1,37,38). The yields in these publications were based on the old method of weekly deep chipping. There are no published data on the relative yields from trees of different diameter with bark chipping and acid treatment, except for one study on trees 4 to 8 inches in diameter (31). A study was started in 1949 to obtain relative information on yields to be expected from trees of different diameters when turpentined by the old untreated weekly deep-chipping method, and by the modern system of acid treatment of bark chipping on a 2-week schedule. This study presents the first real evidence that the same relationship holds true with bark-chipped and acid-treated trees (table 2). In both species the maximum yield in acid treated trees

Table 2.--Comparative gum yields for trees 9 to 13 inches d.b.h. worked by different methods

(In barrels per crop)

Treatment[1/]		Gum yield				Yield per inch of face width			
		1949	1950	1951	Average	1949	1950	1951	Average
SLASH PINE									
Untr. 1/2 x 1/2 wkly									
D.b.h.	9.0- 9.9	133.3	142.3	129.0	134.9	14.03	14.98	13.58	14.20
	10.0-10.9	174.5	201.6	181.6	185.9	16.62	19.20	17.30	17.70
	11.0-11.9	174.3	182.3	184.4	180.3	15.16	15.85	16.03	15.68
	12.0-12.9	229.3	226.6	215.5	223.8	18.34	18.13	17.24	17.90
	13.0-13.9	270.3	280.4	274.1	274.9	20.02	20.77	20.30	20.36
Acid BC x 5/8 bwkly									
D.b.h.	9.0- 9.9	152.8	132.0	105.8	130.2	16.08	13.89	11.14	13.70
	10.0-10.9	191.8	164.1	144.5	166.8	18.27	15.63	13.76	15.88
	11.0-11.9	220.3	193.4	156.0	189.9	19.16	16.82	13.56	16.51
	12.0-12.9	300.6	270.5	261.5	277.5	24.05	21.64	20.92	22.20
	13.0-13.9	300.6	252.3	243.9	265.6	22.27	18.69	18.07	19.67
LSD bbls per crop		47.4	49.9	51.4					
LONGLEAF PINE									
Untr. 1/2 x 1/2 wkly									
D.b.h.	9.0- 9.9	114.1	111.8	110.7	112.2	12.01	11.77	11.65	11.81
	10.0-10.9	124.8	116.6	110.9	117.4	11.88	11.10	10.56	11.18
	11.0-11.9	168.6	162.9	160.0	163.8	14.66	14.16	13.91	14.25
	12.0-12.9	166.7	167.6	163.0	165.8	13.34	13.41	13.04	13.26
	13.0-13.9	217.0	213.6	196.9	209.2	16.07	15.82	14.58	15.49
Acid BC x 5/8 bwkly									
D.b.h.	9.0- 9.9	178.8	145.1	127.0	150.3	18.82	15.27	13.37	15.82
	10.0-10.9	215.5	166.0	159.8	180.4	20.52	15.81	15.22	17.18
	11.0-11.9	248.5	215.0	203.8	222.4	21.61	18.70	17.72	19.34
	12.0-12.9	313.5	247.0	236.7	265.7	25.08	19.76	18.94	21.26
	13.0-13.9	290.9	249.3	223.5	254.6	21.55	18.47	16.56	18.86
LSD bbls per crop		59.1	53.7	54.7					

1/ Treatment with 50-percent sulfuric acid; d.b.h. is diameter breast high in inches.

was obtained from the 12-inch diameter class with yield from the 13-inch class dropping off slightly. Bokor 2/ reported on a similar situation on Pinus sylvestris in Hungary. He found that, ".....with untreated chipping, yield increased with d.b.h., reaching a maximum at about 13.7 inches and then changing little, while with hydrochloric acid treatment the yield increases rapidly with d.b.h., reaching a maximum at about 17.7 inches, then declining." We do not know whether or not a similar situation exists in our species since there is no information available on the higher diameter classes from which to establish a definite trend. However, upon examination of the basic yield data it appears that the drop in yield of the 13-inch class is the result of sampling error rather than an indication of a leveling-off point. The average yields that may be expected in the vicinity of Lake City, Florida, are shown in figures 1 and 2.

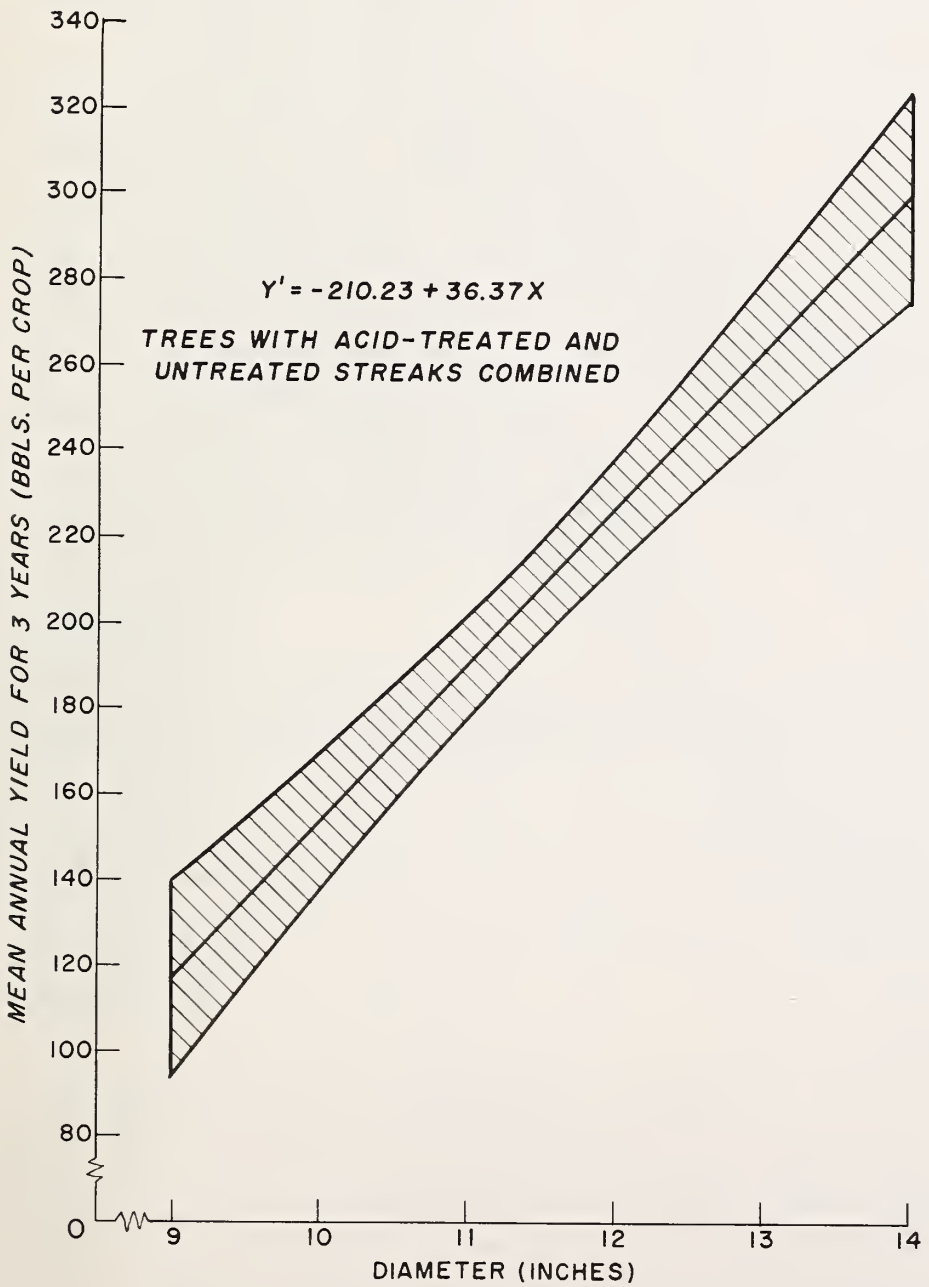

Figure 1.--Relation of gum yield to tree diameter in slash pine. Yields of trees wood chipped every week but not treated, and trees bark-chipped every 2 weeks and treated with acid are combined.

2/ Bokor, R. The intensification of resin production in Hungary. Ann. Fac. Silvat. Univ. Agr. Sopron 1(1): 319-37. 1950.

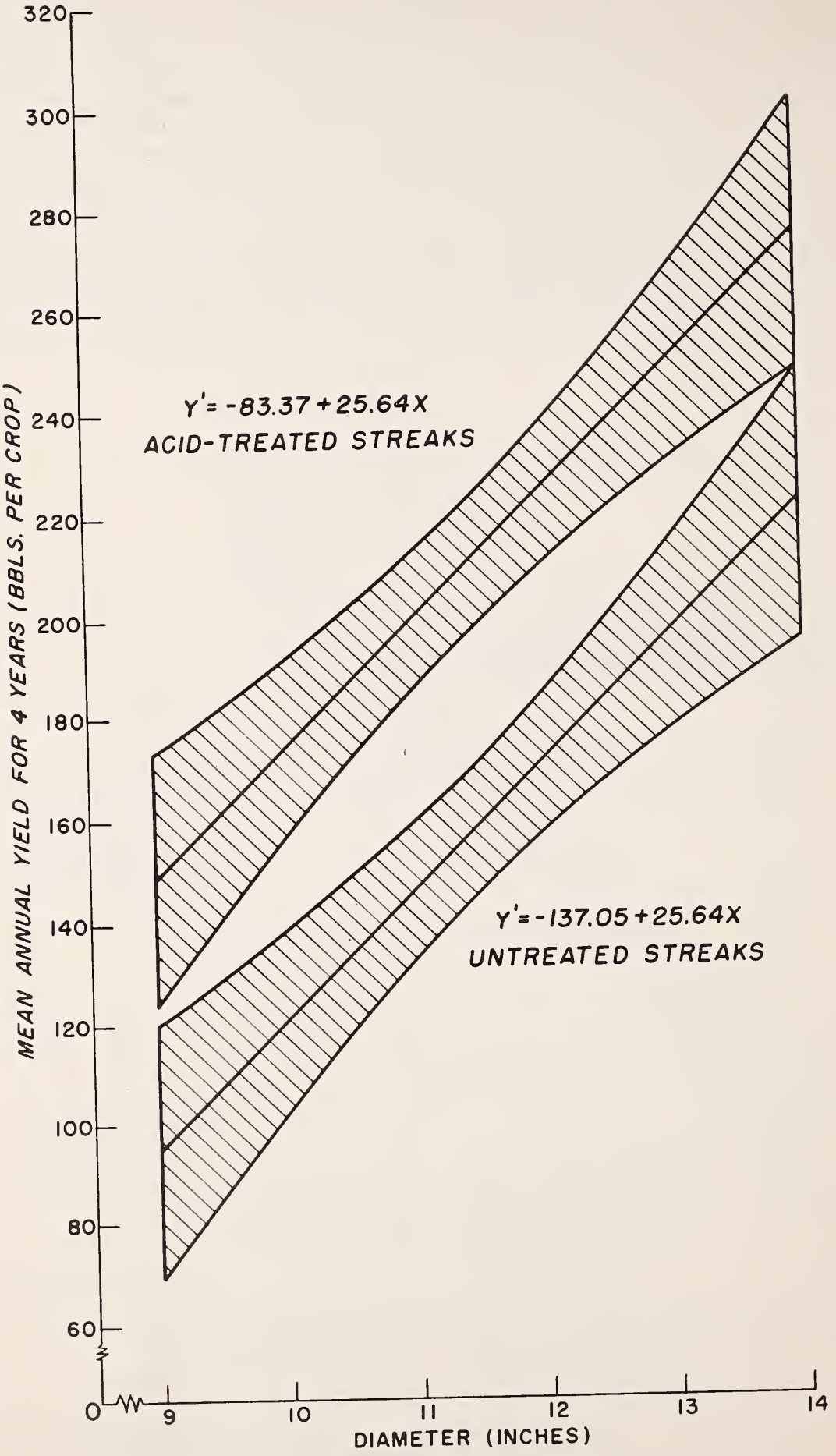

Figure 2.--Relation of gum yield to tree diameter in longleaf pine. Upper line--trees bark chipped every 2 weeks and treated with sulfuric acid. Lower line--trees wood chipped every week and not treated with acid.

Basically one would expect that yields from larger trees would be greater, since face widths of 1/3 circumference were used. Thus larger trees had wider faces, and increased yields might be attributed to these wider faces. However, these data show that tree size has a further influence on yields beyond that of wider faces alone. This is illustrated in the summarized results shown in figure 3. These data also show that the yields per inch of face width are progressively greater as diameters increase.

Many producers ask whether trees smaller than 9 inches in diameter can be worked profitably with modern turpentining methods. A partial answer to this question was given in earlier work (31). At that time, it was felt that some trees in the 8- to 9-inch class could be worked under favorable circumstances. A more intensive study of yields from trees in diameter ranges just below 9 inches gave the results shown in table 3.

The yield level for trees in the 7-inch diameter class is definitely and uniformly low for all treatments in both slash and longleaf. This would be the expected result since the smallest trees were definitely in the intermediate class in a moderately crowded old-field stand. However, yields from 8-inch trees chipped on a biweekly schedule approach the volume needed for a minimum commercial operation. This adds to our previous knowledge and makes it possible to suggest a limited recommendation. These data suggest that 8-inch trees might be worked profitably under specific conditions. We would advocate turpentining of 8-inch trees only if they had good crowns, were not overmature, and only if done prior to intermediate or harvest cuts where removal of these 8-inch trees would benefit the residual stand. Even then, their yield would tend to be marginal, and 8-inch trees should be included mainly for the purpose of making an operable turpentine chance.

Yield Level

Trees vary considerably in their ability to produce gum. This variation is so great that a few outstanding individuals have been segregated for special work in forest tree improvement (11,12). It is possible that at some future time we will have trees in some of our forests which are mainly high yielders (10). In the meantime we have the common mill-run average to turpentine. Preliminary studies of these trees (31) indicated that different yielding categories occurring in the same uniform stands respond differently to acid treatment. This is further illustrated in the results shown in figure 4.

The relative differences in these results are striking and show a definite trend, as indicated in table 4.

The greatest relative yield increase occurred in the trees which were initially classed as low yielders. The smallest increase due to acid treatment was found in the groups of highest yield level. The answer to the question, "Why do high-yielding trees have a lower response to acid than do low-yielding trees?" is probably closely associated with the total amount of gum produced. We have demonstrated in many studies (28,31) that a certain maximum yield level cannot be sustained over any great period of

DIAMETER IN INCHES (DBH)	SLASH BARRELS OF GUM PER CROP	SLASH BARRELS OF GUM PER INCH OF FACE WIDTH	LONGLEAF BARRELS OF GUM PER CROP	LONGLEAF BARRELS OF GUM PER INCH OF FACE WIDTH
9	130	13.7	150	15.8
10	167	15.9	180	17.2
11	190	16.5	222	19.3
12	278	22.2	266	21.3
13	266	19.7	255	18.9

FACE WIDTH
1/3 CIRCUMFERENCE

(ALL TREES BARK CHIPPED AND TREATED WITH ACID EVERY OTHER WEEK)

Figure 3.--Gum yield from trees of different diameter. Yield per crop nearly doubles from 9 to 13 inches, and yield per inch of face width is also greater in larger trees.

Table 3.--Gum yields obtained from trees in different diameter groups with several methods of working

Treatment[1/]	D.b.h.	Gum yield per crop		Relative gum yields	
		1947	1948	1947	1948
	Inches	Bbls.	Bbls.	Percent	Percent
SLASH PINE					
Weekly (untr.)	9+	212.7	220.7	100	100
Biweekly (acid)	7-8	100.7	106.5	47	48
	8-9	131.1	134.6	62	61
	9+	207.0	230.9	97	105
Triweekly (acid)	7-8	66.0	80.9	31	37
	8-9	83.1	99.1	39	45
	9+	124.7	142.0	59	64
LSD bbls per crop		39.2	44.8		
LONGLEAF PINE					
Weekly (untr.)	9+	141.7	137.1	100	100
Biweekly (acid)	7-8	92.3	80.7	65	59
	8-9	135.3	125.4	95	91
	9+	161.8	150.7	114	110
Triweekly (acid)	7-8	63.3	77.9	45	57
	8-9	92.4	106.8	65	78
	9+	116.0	122.4	82	89
LSD bbls per crop		28.9	36.6		

1/ Weekly trees chipped 1/2 x 1/2; others bark chipped 1/2-inch high. Face widths all 1/3 circumference; sulfuric acid in a concentration of 40 percent for slash and 60 percent for longleaf pine.

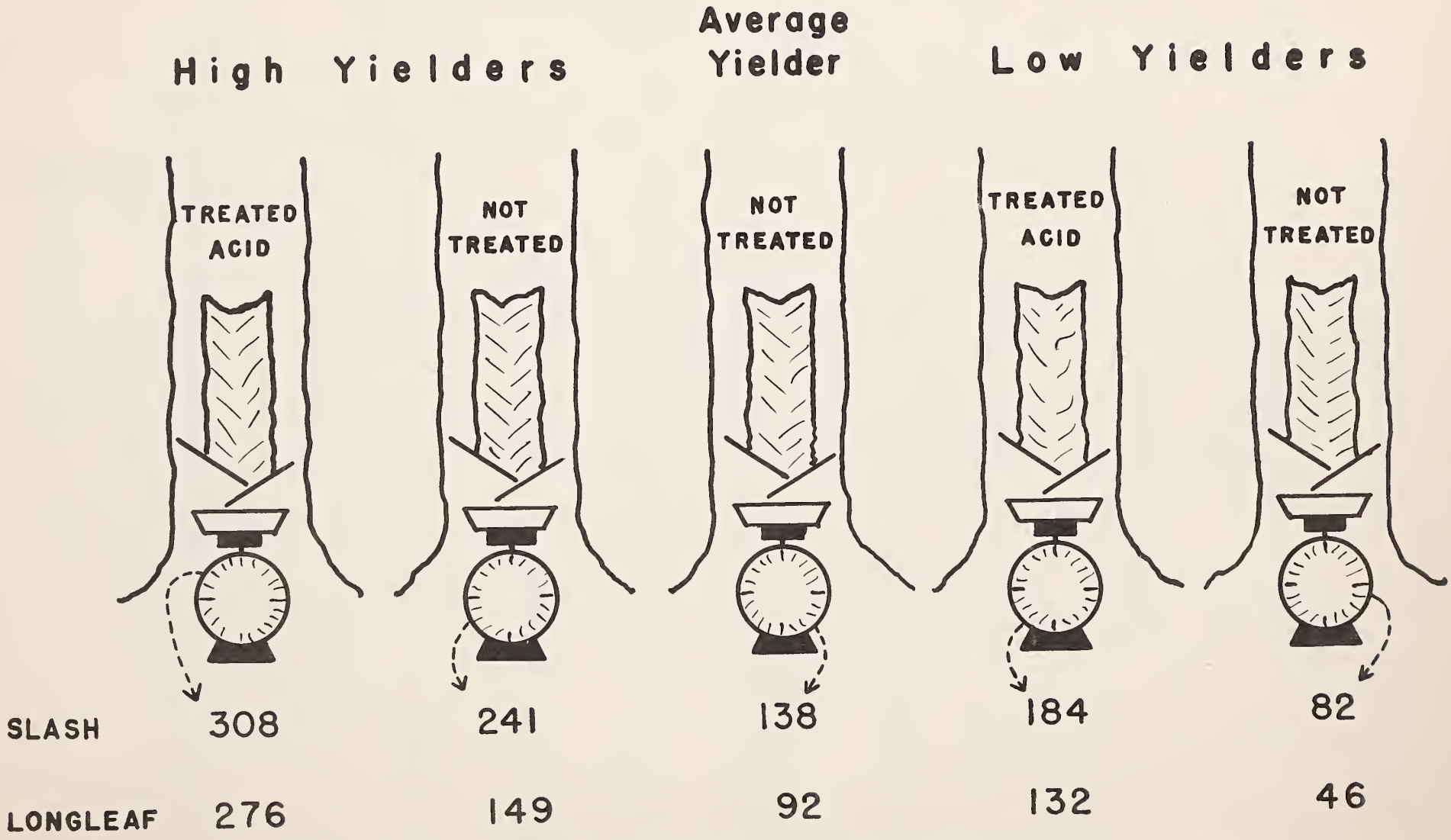

Figure 4.--The effect of acid treatment on yields from high- and low-yielding trees (in barrels per crop).

Table 4.--Relative yield differences for treated and untreated trees of three yield levels

Yield level	Relative difference[1]	
	Slash	Longleaf
	Percent	Percent
High	28	85
Average	86	76
Low	124	187

1/ Percent figures represent the percent yield increase due to acid treatment.

time. High yielders are already producing more gum than average trees. Yield trends show that initially in high yielders the yield boost given by acid lasts for only about 3 months (31). In contrast to this, the yield boost given low yielders by acid is prevalent during most of the season. We can then conclude that temporarily the continuous-yielding ability of high yielders is exceeded, but in low yielders it is not.

Frequency of Chipping and Treatment

One of the most important factors determining the efficiency of turpentining with modern methods is the frequency with which the trees are chipped and treated. In the old days of deep chipping the trees were visited about once a week during the regular season. Sometimes during the hot months of July and August more frequent visits were made to chip the trees (1). There was an abundant supply of labor in those days.

Now the picture is different, with labor hard to get and difficult to keep. But with less labor and the use of modern bark chipping and acid treatment, the turpentine operator can still produce as much gum as before and produce it more efficiently. This involves the use of chipping intervals of 2 weeks. A laborer can handle nearly twice as many trees, and with the increased yield resulting from the use of acid produce as much gum as two men working with old-fashioned methods.

Because of the importance of the frequency of chipping and treatment, considerable work has been reported previously (2,3,4,5,6,7,28,30,31) on this subject. These publications have covered most of the advantages of the several frequencies that may be used, and point out which will be best for any given situation. Also, most of the other work reported in this paper contains information on the relative efficiencies of schedules of 1-, 2-, or 3-week chipping intervals.

Additional work not reported before is summarized in table 5. This study covers 6 years of front-face work, and an additional 2 years of back-face results. Although general yield levels are low, the yields over the entire period of 8 years are good with a 3-week chipping and treatment schedule. This 3-week schedule is particularly good in longleaf, and further emphasizes identical results of infrequent schedules obtained in other longleaf experiments. Slash pine results are not so outstanding, but on the basis of yield per streak, compare favorably with regular weekly deep chipping.

Table 5.--Comparative gum yields for 8 years of work by two different treatment methods

(In barrels per crop)

Treatment[1/]	Front face						Backface	
	1944	1945	1946	1947	1948	1949	1950	1951
SLASH PINE								
Weekly								
1/2 x 1/2 Untr.	166.6	175.0	206.1	232.9	247.4	229.9	150.2	176.5
Triweekly								
BC + Acid	124.9	126.2	146.2	100.3	162.4	160.8	123.7	150.0
LONGLEAF PINE								
Weekly								
1/2 x 1/2 Untr.	99.5	88.0	96.9	98.3	115.5	95.7	81.5	84.1
Triweekly								
BC + Acid	118.5	123.6	105.2	80.9	109.1	112.2	69.9	107.6

1/ Triweekly groups were bark chipped 3/4 inch high on front faces, and 5/8 inch on back faces; a sulfuric acid concentration of 40 percent on slash and 60 percent on longleaf was used through 1949, and a 50-percent concentration for both species in 1950 and 1951.

The 8-year results in table 5 further strengthen the concept of no tree damage with the use of acid, shown in a successful 5 years of work with a biweekly schedule, previously reported (30). This test also gives us a preliminary indication that back-face yields with acid closely follow those of front faces.

Chipping Height

Observations on field procedures used in commerical operations show a wide difference in the height of bark chipping, with streak heights generally ranging from 1/2 inch to 1 inch. Chipping height is an important point of technique, and is influential in determining gum yields. No single height of bark chipping can be recommended for all situations. Evidence is available, however, that indicates the ideal height to use for specific circumstances (28,31).

A previous publication (32) discusses the relative differences in gum yield to be expected from different heights of bark chipping when acid is used on a 2-week schedule. The conclusions reached were: "....under average conditions of bark chipping and acid treatment on a 2-week schedule for a period of about 5 years, a chipping height of 1/2 inch is best. However, if trees are to be worked for a shorter period, or if a 3-week chipping and treating schedule is used on longleaf pine, the chipping height can be increased to 5/8 or 3/4 inch."

In general the data from another experiment, shown in table 6, tend to support this previous recommendation. In addition, further information on the intermediate chipping height of 5/8 inch is given. Under all the schedules used, gum yield increased progressively with height of chipping from 1/2 to 3/4 inch. These results are for a 3-year period only, however, and after two more seasons of work, the relationships might be slightly changed.

When we compare the yield results in table 6 for a triweekly schedule of bark chipping and acid treatment, with the old method of untreated deep chipping, a bark chipping height of 3/4 inch stands out as giving equivalent gum yields. This is a very important practical point because of the much greater efficiency obtained with a 3-week chipping and treating schedule. Thus, for those operators who have low nonlabor costs and who are interested in greatest net profits with a limited labor supply, a 3-week schedule of bark chipping and acid treatment at a chipping height of 3/4 inch is the best method to use.

For those operators interested in either prolonging the working life of a face or reducing the final height of this face, lower chipping heights of 1/2 or 5/8 inch will provide these results.

Width of Face

Under some conditions turpentine producers wish to get maximum yields in a relatively short time. One way they can do this is to speed up the frequency of chipping at the same time they increase chipping height. A more efficient method for them to use might be to maintain their present chipping frequency of every other week, but increase the width of the face and the height of chipping. This general recommendation was indicated by results of a previous experiment that ran for two years (31). Further data, with four seasons of work, are given in table 7.

The widest face used--2/3 circumference--was definitely not practical. At no time did yields from faces 2/3 circumference in width equal twice those from normal-width faces of 1/3 circumference. As a 4-year average, yields

Table 6.--Comparative gum yields with three different chipping heights

SLASH PINE

Treatment[1/]	Yield per crop				Relative yield
	1949	1950	1951	Average	
	Bbls.	Bbls.	Bbls.	Bbls.	Percent
Weekly untr. 1/2 x 1/2	178.7	203.9	217.8	200.1	100
Biweekly BC x 1/2	242.7	256.7	251.3	250.2	125
Biweekly BC x 5/8	258.4	263.6	256.4	259.5	130
Biweekly BC x 3/4	277.9	266.6	262.2	268.9	134
Triweekly BC x 1/2	151.9	164.7	186.4	167.7	84
Triweekly BC x 5/8	188.2	178.0	205.3	190.5	95
Triweekly BC x 3/4	200.7	202.4	231.7	211.6	106
LSD bbls per crop	48.8	53.8	57.1		

LONGLEAF PINE

Weekly untr. 1/2 x 1/2	164.6	137.2	129.0	143.6	100
Biweekly BC x 1/2	179.2	129.0	124.5	144.2	100
Biweekly BC x 5/8	211.2	148.5	148.9	169.5	118
Biweekly BC x 3/4	251.9	190.0	184.4	208.8	145
Triweekly BC x 1/2	127.4	106.3	101.8	111.8	78
Triweekly BC x 5/8	155.2	121.8	116.5	131.2	91
Triweekly BC x 3/4	165.3	140.8	126.5	144.2	100
LSD bbls per crop	38.8	34.9	30.6		

1/ All bark-chipped groups were treated with 50-percent sulfuric acid; all face widths 1/3 circumference.

Table 7.--Comparative gum yields at different chipping frequencies for 3 face widths

SLASH PINE

Treatment[1/]	Gum yield per crop					Relative yield
	1947	1948	1949	1950	Average	
	Bbls.	Bbls.	Bbls.	Bbls.	Bbls.	Percent
Weekly (1/3 cir.)						
Untr. 1/2 x 1/2	212.7	220.7	221.8	227.4	220.6	100
Acid BC x 1/2	302.1	261.5	231.6	225.9	255.3	116
Biweekly (BC x 1/2)						
F.w. 1/3 cir.	207.0	230.9	212.3	210.5	215.2	98
F.w. 1/2 cir.	215.9	216.5	188.3	173.4	198.5	90
F.w. 2/3 cir.	287.7	316.4	267.1	250.5	280.4	127
Triweekly (BC x 1/2)						
F.w. 1/3 cir.	124.7	142.0	134.9	142.6	136.0	62
F.w. 1/2 cir.	162.1	182.6	172.0	173.9	172.6	78
F.w. 2/3 cir.	188.6	199.3	180.1	176.2	186.0	84
LSD bbls per crop	39.2	44.8	58.3	62.3		

LONGLEAF PINE

Weekly (1/3 cir.)						
Untr. 1/2 x 1/2	141.7	137.1	140.0	131.3	137.5	100
Acid BC x 1/2	268.3	227.4	199.7	172.8	217.0	158
Biweekly (BC x 1/2)						
F.w. 1/3 cir.	161.8	150.7	152.8	135.2	150.1	109
F.w. 1/2 cir.	201.0	190.6	196.5	173.6	190.4	138
F.w. 2/3 cir.	241.2	229.8	213.2	189.2	218.4	158
Triweekly (BC x 1/2)						
F.w. 1/3 cir.	116.0	122.4	108.3	101.9	112.2	82
F.w. 1/2 cir.	164.9	157.2	145.4	127.3	148.7	108
F.w. 2/3 cir.	171.7	168.8	145.4	128.6	153.6	112
LSD bbls per crop	28.9	36.6	50.2	46.5		

1/ In 1947-9 inclusive a 40-percent concentration of sulfuric acid was used for slash and a 60-percent concentration for longleaf; a 50-percent solution was used for both species in 1950. "F.w. ( ) cir." indicates the face width as a fraction of the circumference.

from double-width faces were only 30 and 46 percent greater than faces of normal width on a biweekly schedule for slash and longleaf, respectively, or 37 percent greater on a triweekly schedule for both species. The highest relative difference was 51 percent for the first year in the slash pine triweekly groups. This amount of increase is probably not sufficient to meet the increased chipping and tin installation costs of the wider faces. In general yields from double-width faces declined moderately for all groups during the 4 years of work.

The yield relationships for faces 1/2 circumference in width were much more favorable from a practical standpoint. Except for the biweekly slash groups, yields averaged nearly 30 percent greater for faces 1/2 circumference in width than those 1/3 circumference. Since increased tin-installation costs would be relatively small on 1/2 circumference faces, and chipping costs could be expected to be only slightly greater, this method offers promise in increasing yields and profits. However, the use of faces 1/2 circumference in width would mainly be limited to circumstances where only one face was to be turpentined just prior to harvesting of the tree.

Another factor to consider is that similar yield increases approximating 30 percent could be obtained by merely increasing the chipping height from 1/2 inch, as used in this study, to 3/4 inch on faces 1/3 circumference in width. Obvious advantages are offered by the latter method, even though the ultimate total face height would be somewhat greater. However, further augmented yields might be obtained by using a 3/4-inch chipping height on faces 1/2 circumference in width. An experiment with the partial objective of determining whether this was true is reported in table 8.

These results show that a chipping height of 3/4 inch did not materially increase yields from faces 1/2 circumference in width. This was an unexpected result, since we previously thought that yields might be increased in faces 1/2 circumference in width if greater chipping heights were used. With the 1/3 circumference faces, however, yields were greater with increased chipping height. It is possible that the "treatment intensity" level of faces 1/2 circumference in width is such that physiologically the tree is not capable of sustaining a further yield increase that might be induced by a greater chipping height. This evidence further supports the conclusions reached in the discussion under the heading "Diameter" concerning the maximum yield level capability of a tree.

Number of Faces

When more than one face is placed on a single tree, the actual costs of operation are almost the same as if these extra faces were on other trees. Consequently, when determining the efficiency of any multiple cupping method, the yield per face is the important factor. Earlier studies (28,31) explored the possibilities of more than one face per tree. In spite of very large initial yields from trees with many faces, maximum sustained yields were uniformly obtained from trees with no more than two faces for a 2-year period. One of these studies in which tree diameters ranged from 9 to 13 inches b.h., was continued for an additional 2 years of work. Results are shown in table 9.

Table 8.--Comparative gum yields for trees with different frequencies of chipping, height of chipping, and width of face

(In barrels per crop)

Treatment[1]		Average gum yield per crop[2]	
		Slash	Longleaf
Weekly Untr. 1/2 x 1/2		191.3	150.9
Biweekly			
F.w. 1/3 cir.	BC x 1/2	249.7	154.1
	BC x 5/8	261.0	179.8
	BC x 3/4	272.2	221.0
F.w. 1/2 cir.	BC x 1/2	312.0	201.1
	BC x 5/8	290.2	223.6
	BC x 3/4	289.2	214.8
Triweekly			
F.w. 1/3 cir.	BC x 1/2	158.3	116.8
	BC x 5/8	183.1	138.5
	BC x 3/4	201.6	153.0
F.w. 1/2 cir.	BC x 1/2	218.7	172.3
	BC x 5/8	215.3	165.6
	BC x 3/4	225.8	171.1

1/ All groups treated with 50-percent sulfuric acid except the trees on a weekly schedule, which were untreated. "F.w. ( ) cir." indicates the face width as a fraction of the circumference.

2/ Average for 2 years of work.

Although 2-year yields were good, the yield per face (two-faced, acid-treated trees), compared to a single face on untreated controls, fell off considerably the fourth year, being 32 and 39 percent lower for slash and longleaf respectively. Yields the first 3 years averaged 1 percent greater for each face in slash, and 15 percent greater in longleaf, for the trees receiving weekly acid treatment and bark chipping. The 4-year average was 10 percent less for slash pine and 2 percent more for longleaf.

A realistic look at the gum-yield figures in table 9 shows that yield totals, on which potential practical methods must be based, were higher for each of the treated faces on double-cupped trees for only 2 years in slash and 3 years in longleaf. Thus, if weekly chipping can be practiced, it might be possible to work profitably two faces with bark

Table 9.--Gum yields from single- and double-faced trees

SLASH PINE

Treatment[1]	No. of faces	Gum yield per crop[2]				
		1945	1946	1947	1948	Average
		Bbls.	Bbls.	Bbls.	Bbls.	Bbls.
Untr. 1/2 x 1/2	1	155.6	179.2	198.1	239.8	193.2
Acid BC x 1/2	2	181.6	185.5	168.9	162.0	174.5

LONGLEAF PINE

Untr. 1/2 x 1/2	1	144.5	153.1	152.1	195.3	161.3
Acid BC x 1/2	2	191.1	175.6	152.6	138.8	164.5

1/ Face-width 1/3 circumference on single-face trees; 4/10 circumference each on two-face trees. A weekly chipping schedule was used.
2/ Yield per crop of faces (10,000).

chipping and acid treatment for 2 years in slash pine and 3 years in longleaf pine. However, since a 2-week chipping and treatment schedule is much more efficient, it is doubtful whether the average stand of turpentine timber, with diameters averaging 10.5 inches, should be cupped with two faces per tree, since the yields per face tend to be marginal on a 2-week schedule.

The best information we have to date on the lowest diameter tree that can profitably be worked with two faces is contained in the discussion of "Diameter" in this paper. Here, it appears that two faces on trees larger than 13 inches constitute a good method to use if a biweekly schedule of bark chipping with acid treatment is followed.

Split Faces

Observation shows us that gum flow is greatest from the portion of the streak near the shoulder, and least from the portion near the center of the face. We can easily postulate a physiological basis for this fact. Lowered activity near the center of the face may result from decreased available quantities of water, mineral elements, and transported carbohydrates used as gum precursors.

In order to overcome these possible deficits, we thought that by decreasing the face width by one-half and providing a live bark-bar between these smaller faces increased gum yields might be obtained. However, experimental studies have been contradictory and further testing is necessary.

From a practical standpoint, tin installation costs are only slightly increased for split-face work, since a single cup and gutter installation can be used (9). However, in the initial stages of field work, increased supervision (8) is needed to train the laborers to keep the bark-bars intact, the face widths uniform, and the side lines vertical.

Acid Concentration

Early experiments in the use of sulfuric acid were made with low concentrations of 5 to 20 percent by weight (13). Later work showed that a 40-percent concentration was effective on slash pine, but did not produce expected results on longleaf (14,15). Further research revealed that at a concentration of 60 percent longleaf responded favorably (28).

As slash and longleaf often are included in a single drift, this posed a difficult treatment problem, since it was not feasible to carry two spray bottles at the same time, each with a different acid concentration. Also, optimum yields would never be obtained in mixed stands when either strength of acid was used alone. Thus there was need for a single acid concentration of maximum effectiveness for both species. The study summarized in table 10 was conducted to solve this problem.

These results show that a sulfuric acid concentration of 50 percent works equally well for both slash and longleaf pine over a 5-year period. On the average, the yields from trees treated with a 50-percent acid concentration were slightly greater for each species than the yields from trees receiving the formerly recommended concentrations of 40 percent for slash and 60 percent for longleaf pine.

No further refinements in acid concentration appear necessary, since yield variations due to amount of acid applied could be greater than any yield change due to a slightly different acid concentration. From a practical standpoint it is important to obtain uniform coverage of the entire freshly cut streak with the correct amount of acid (26). This amount will change to meet varying needs of weather and stand conditions. The quantity of acid should be reduced during dry spells, particularly on the poorer sites with crowded stand conditions, and with over-mature trees with small crowns. A healthy, vigorously growing tree with adequate moisture should receive the equivalent of 1 cc. of acid per 8 inches of face width (17).

Other Chemicals

Of the many different chemicals tested since the last comprehensive report on chemical stimulants (31), only 2,4-D (2,4-dichlorophenoxyacetic acid) has offered any real promise as a substitute for sulfuric acid. A noncorrosive chemical such as 2,4-D would be much safer to use, and would eliminate the necessity of acid-proof equipment.

Briefly, it should be emphasized now that, although 2,4-D appears satisfactory for use on pure slash pine according to the latest studies, 2,4-D is not recommended for general use, particularly in longleaf, as excessive mortality occurs in longleaf pine stands turpentined with the use of 2,4-D.

Table 10.--Gum yields from trees treated with different concentrations of sulfuric acid

SLASH PINE

Treatment[1]	Gum yield per crop[2]						Relative yield
	1947	1948	1949	1950	1951	Average	
	Bbls.	Bbls.	Bbls.	Bbls.	Bbls.	Bbls.	Percent
Weekly (1/3 cir.)							
Untr. 1/2 x 1/2	183.8	200.1	235.2	276.9	240.3	227.3	100
40% Acid BC x 1/2	287.2	255.5	237.7	241.3	224.3	249.2	110
50% Acid BC x 1/2	332.0	296.6	288.6	280.7	251.5	289.9	128
Biweekly (1/3 cir.)							
40% Acid BC x 1/2	230.2	254.7	259.4	251.0	232.8	245.6	108
40% Acid BC x 3/4	257.8	272.2	250.3	223.4	216.3	244.0	107
50% Acid BC x 1/2	217.1	214.4	220.8	206.5	179.0	207.6	91
50% Acid BC x 3/4	270.6	308.0	282.2	263.2	246.7	274.1	120
LSD bbls per crop	57.1	65.3	63.8	70.8	87.3		

LONGLEAF PINE

Weekly (1/3 cir.)							
Untr. 1/2 x 1/2	125.3	128.5	133.2	135.7	104.4	125.4	100
50% Acid BC x 1/2	205.1	187.7	186.1	149.8	130.4	171.8	137
60% Acid BC x 1/2	211.3	199.9	191.2	145.2	139.8	177.5	142
Biweekly (1/3 cir.)							
50% Acid BC x 1/2	142.2	139.9	139.1	118.6	112.4	130.4	104
50% Acid BC x 3/4	183.6	193.8	181.0	149.9	134.4	168.5	134
60% Acid BC x 1/2	114.5	125.2	117.9	98.5	92.5	109.7	87
60% Acid BC x 3/4	141.8	164.5	164.5	131.4	130.7	146.6	117
LSD bbls per crop	51.4	37.4	37.4	35.8	32.1		

1/ Sulfuric acid used.
2/ Yield per crop of 10,000 faces.

Early experiments, summarized in table 11, indicated that at concentrations of 4 or more percent, solutions of 2,4-D do not result in yields equal to those from sulfuric acid treatment in either slash or longleaf pine. Even with a "biweek-skip" system of treatment (chip every second week and treat every fourth week), which is one of the least intensive used in our experiments, 20 percent of the treated longleaf trees died. Even higher percentages of loss occurred in some of the other 2,4-D treatment groups, with some longleaf trees dying the following year. These 1948 results definitely indicated that the concentration was too high, and was particularly unsuited for longleaf.

Table 11.--Comparative gum yields for trees treated with different chemicals at various concentrations

Treatment[1]	SLASH		LONGLEAF	
	Yield	Relative yield	Yield	Relative yield
	Bbls.	Percent	Bbls.	Percent
Weekly				
Untr. 1/2 x 1/2	297.2	100	162.0	100
Biweekly				
50% sulfuric acid	237.1	80	186.0	115
20% sulfamic acid	241.2	81	99.3	61
4% 2,4-D	241.2	81	115.5	71
6% 2,4-D	259.5	87	115.4	71
8% 2,4-D	253.2	85	102.0	63
Biweekly-skip[2]				
6% 2,4-D	226.2	76	126.3	78
8% 2,4-D[3]	264.4	89	131.5	81
LSD bbls per crop	60.5		34.4	

1/ Results for 1948. All treated groups were BC x 1/2 except the group with dust treatment, which was BC x 3/4. Yield per crop of 10,000 faces.

2/ Chipping every second week and treating every fourth week.

3/ Last 20 weeks of season pure 2,4-D dust was used, instead of the 8-percent 2,4-D solution, on a biweekly schedule.

In 1949 a small study of weaker 2,4-D concentrations was started in slash pine. The 3-year data summarized in table 12 show that a 2-percent 2,4-D treatment resulted in consistent yields for the entire period, essentially equivalent to those to be expected from sulfuric acid treatment. This encouraging trend suggested that some of the weaker 2,4-D concentrations might be suitable for longleaf, and some intermediate concentration even better for slash pine.

Close examination of the relative yields from the different treatments shows that the yields from those with the weakest concentration (table 12) were about 20 percent less than the controls. This level is about what one would expect from untreated bark chipping. Thus we could conclude that at a concentration of 0.5 percent the 2,4-D had no effect on yields. Also, since a 1.0-percent concentration resulted in yields about the same as the deep-chipped controls, particularly the first year, this concentration had a slight effect on yields.

Table 12.--Comparative gum yields for trees treated with different concentrations of 2,4-D

SLASH PINE

Treatment	Gum yield per crop[1/]				Relative yield
	1949	1950	1951	Average	
	Bbls.	Bbls.	Bbls.	Bbls.	Percent
Weekly (1/2 x 1/2)					
Untreated	176.0	206.8	223.4	202.1	100
Biweekly (BC x 1/2)					
0.5% 2,4-D	144.0	173.3	165.4	160.9	80
1.0% 2,4-D	178.2	191.8	186.2	185.4	92
2.0% 2,4-D	243.1	254.5	239.0	245.5	121
LSD bbls per crop	31.8	41.0	43.1		

1/ Yield per crop of 10,000 faces.

Results of an experiment incorporating a wide range of treatments with 2,4-D solutions in concentration steps of 0.5 percent are given in table 13. These data show that for the 2-year period a 2-percent 2,4-D solution was best in slash pine. This substantiates the results of the study reported in table 12. These data also show again that 2,4-D in all the concentrations used does not produce a satisfactory yield response in longleaf. In addition, up to 40 percent of the longleaf trees died in some of the groups.

Table 13.--Comparative gum yields for trees treated with different concentrations of 2,4-D and worked by several methods

SLASH PINE

Treatment[1/]	Yield per crop			Relative yield
	1950	1951	Average	
	Bbls.	Bbls.	Bbls.	Percent
Weekly				
Untr. 1/2 x 1/2	184.9	188.9	186.9	100
Biweekly (BC x 5/8)				
50% Acid	216.4	194.5	205.4	110
0.5% 2,4-D	164.4	168.0	166.2	89
1.0% 2,4-D	212.8	210.5	211.6	113
1.5% 2,4-D	207.3	--	--	--
2.0% 2,4-D	250.4	233.4	241.9	129
2.5% 2,4-D	225.8	--	--	--
3.0% 2,4-D	230.2	227.1	228.6	122
Split face (Bwkly)				
50% Acid BC x 5/8	309.5	289.4	299.4	160
1.5% 2,4-D BC x 5/8	244.7	268.6	256.6	137
LSD bbls per crop	43.7	55.2		

LONGLEAF PINE

Weekly				
Untr. 1/2 x 1/2	160.9	158.2	159.6	100
Biweekly (BC x 5/8)				
50% Acid	177.3	152.0	164.6	103
0.5% 2,4-D	121.9	--	--	--
1.0% 2,4-D	119.7	--	--	--
1.5% 2,4-D	122.2	--	--	--
2.0% 2,4-D	112.2	--	--	--
2.5% 2,4-D	120.5	--	--	--
3.0% 2,4-D	123.1	--	--	--
Split face (Bwkly)				
50% Acid BC x 5/8	188.4	190.3	189.4	119
1.5% 2,4-D BC x 5/8	131.0	--	--	--
LSD bbls per crop	39.8			

1/ Sulfuric acid used.

Although 2,4-D offers promise as a substitute for sulfuric acid in treating slash pine, from a practical standpoint industry is not urged to try this chemical, even for slash pine. The main reason for this caution is the fact that 2,4-D causes excessive mortality when applied to longleaf streaks, and indiscriminate use by unskilled labor would inevitably lead to longleaf trees being treated. Treatment of these longleaf with 2,4-D will lead to the early death of up to 50 percent or more of the trees. Work on suitable 2,4-D treatment methods for longleaf pine is under way. Until a safe method is found for longleaf, 2,4-D is not recommended for general use in turpentining. Sulfuric acid still remains the best chemical to use.

Year of Work

Commonly in the past, yield declines have been noted in the latter years of working a face. Most of this decline has been associated with deep incisions, with the greatest decline noted (16) in the days of the cut box. Even with broadaxe incisions, decreases in yields occurred in successive years of work. Wyman (38) indicated that gum yields from longleaf pine trees declined about 30 percent in 5 years, or an average of 6 percent annually; yields in slash pine fell off slightly more. In other tests, with careful gutter insertions (1), yield declines were less; in fact, second year yields were often higher than those of the first year, with only a 10-percent drop in the 5 years of work.

A different picture is presented when modern turpentine methods are used. In almost all the experiments reported in this paper the tins were fastened on to the outside of the wood or smoothed bark with no insertions. As a consequence, none of the data showed consistent annual yield declines over long periods, except for those treatments that were definitely too intensive in character.

The differences observed can generally be attributed to specific causal agents, as previously discussed where pertinent. The causes include such factors as drought, insect depredations, and particularly the intensity of the specific treatment used. Thus, no clear-cut simple statement can be made to answer the general question of how yields vary in successive years of turpentining with bark chipping and sulfuric acid treatment. We do know, however, that conservative tin installation methods and conservative treatments lead to a fairly sustained level of yield over a number of years of work.

Winter Work

Many producers would like to have a winter income to help defray the carrying costs of the many winter jobs that have to be done, and to help keep a working group intact. One solution to this problem, when the old method of deep chipping was used, was a monthly streak applied between regular seasons. Yields were fair with this system. More recently some operators have used acid intermittently during the winter, and many have asked whether this practice is sound.

For two reasons we have previously advised against winter work with acid (34). First, poor yields have resulted in early experiments with weekly chipping and treatment on a continuous schedule through the winter

and the following season (25,28,34). Second, acid-killing of tissues above the face (25,27) has been excessive when this tissue is allowed to remain undisturbed for 4 weeks, and subsequent yields have been lower. However, we then lacked data on yields from winter work with other chipping schedules. A recent experiment gave us some preliminary information on other chipping and treatment schedules. This data is summarized in table 14.

Table 14.--Relative gum yields from longleaf worked in winter

Basic treatment	Yield in 1950	Winter yield 1/	Yield in 1951	'51 yield as percent of '50	Theoretical yield based on control 2/	Winter yield plus 1951 yield
	Bbls.	Bbls.	Bbls.	Percent	Bbls.	Bbls.
Wkly. Untr.	131.3	--	118.2	90.0	118.2	118.2
Wkly. Acid	172.8	12.8	125.7	72.7	155.5	138.5
Bwkly. Acid	135.2	17.7	104.0	76.9	121.7	121.7
Twkly. Acid	101.9	18.9	72.2	70.8	91.7	91.1
LSD bbls per crop	46.5		32.0			

1/ The untreated group was rested during the winter; other groups were on a triweekly bark chipping schedule with acid during the winter; in 1951 regular treatments were resumed.

2/ Yields of treated groups are in the same proportion to the 1950 yields as those of the untreated control group which rested during the winter, and represent the theoretical yields assuming normal winter rest and uniform seasonal fluctuation.

Several important trends are evident from these results. First, yield declines in all groups worked during the winter were greater than the seasonal fluctuation shown by the control group. In other words, winter work caused a decrease in yields during the next regular season of work. Second, this decrease in yields is equalized by adding winter yields to those of the following season in groups on a biweekly and triweekly schedule, but not in the group on a weekly schedule. This indicates that a weekly chipping and treatment schedule may be too severe to be maintained over successive years of work. This confirms results of other experiments (31). However, the lower yields of the weekly group in 1951, when compared to 1950, may also have been due in part to the usual decline in yields from year to year at this chipping frequency, which was increased by winter work.

Although the total of winter and 1951 season's yields approach those that might be expected from trees with a winter rest period, the added costs of chipping and treating during the winter place winter working in a more doubtful position.

If the efficiency of each type of treatment is considered, the yields in table 15 will give some indication of the relative value of each method.

Table 15.--Relative gum yields from longleaf for the data in table 14

Basic treatment[1/]	Gum yield per streak per 1,000 faces		
	1950	Winter	1951
	Bbls.	Bbls.	Bbls.
Weekly untreated	0.41	--	0.37
Weekly acid	.54	0.26	.39
Biweekly acid	.84	.35	.65
Triweekly acid	.92	.38	.66

1/ The untreated group was rested during the winter; other groups were on a triweekly bark chipping schedule with acid during the winter; in 1951 regular treatments were resumed.

It is quite obvious that for the labor expended, yields from triweekly chipping during the regular season are the highest. But to meet the requirements of fixed costs, greater total yields for the season (table 15) may be considered more important, which would make the biweekly schedule more attractive when considered from both standpoints.

Although the general yield level for this longleaf plot is low, it is still about the same as that obtained in some of the commercial operations in this area, and winter yields per streak are not far from those using weekly untreated chipping. So, from this standpoint, winter working may be practical, but the efficiency is not as great as could be desired.

The problem of winter work becomes increasingly important as more and more producers change over to the use of bark chipping and acid. Many of these new acid users previously have done winter work with untreated deep chipping as a regular part of their yearly schedule. They will be faced with the immediate problem of deciding whether to do winter work when using bark chipping and acid. To date we do not have a clear-cut answer to this problem. But we do know that equivalent yields are obtained with a 3-week winter schedule with acid, that the following year's yields are somewhat reduced because of winter work, and that the over-all efficiency is lower. To balance these latter drawbacks, we have the benefits of keeping a working crew together, and there is a small winter income for the producer to use in defraying other winter costs. Further intensive studies on this problem are under way to provide more basic data on the relative merits of winter work.

Clean-up Streak

When trees are treated with acid, it is necessary to remove the acid-killed tissue that results from the last treated streak of the season before maximum yields can be obtained during the first part of the next season's work. This may be done either in the fall or as part of the initial spring operation, provided the trees are rested during the winter. Either time of doing this necessary task has both advantages and disadvantages, as previously discussed (35).

An untreated streak put on in the fall removes acid-killed tissue above turpentine faces and helps to provide early gum yields from the first treated streak put on the following spring. Schopmeyer (27) concluded that the fall clean-up streak simplified labor supervision, and that a lower clean-up streak was needed in the fall than in the spring, particularly in longleaf. However, gum yields from untreated clean-up streaks in the fall are very low, and it may be difficult to persuade laborers to make this bark-chipped streak if they are being paid on a rental basis.

As indicated before (35) the average height of a clean-up streak, when made in the fall, is close to 1 inch for both slash and longleaf. This conclusion is based on 2500 observations made in two different seasons. The range of heights needed to reach clear white wood, among the many individual trees tested, varied from as little as 1/2 inch to as much as 1-1/2 inches. Of the many types of treatments sampled, no great difference in the average required chipping heights for the clean-up streak was found because of acid concentration, height of chipping, width of face, or tree diameter.

If the producer elects to make a combination spring clean-up streak and initial treated streak, the chipper should chip at least a double streak. In slash pine two full hack streaks with a 1/2-inch bark hack will be sufficient to remove most of the killed tissue. In longleaf most killed tissue can be removed with two full streaks with a 5/8-inch bark hack.

Although a greater height of tissue must be removed in the spring than in the fall, the fall clean-up streak still requires double chipping in most cases. The only difference is that in the fall two streaks, each less than the full width of the hack, are made, while in the spring two full hack streaks are needed. Thus no saving in labor is obtained by making the clean-up streak in the fall rather than in the spring.

The strongest single argument for a spring clean-up streak is the much greater yields obtained then because of the acid applied to this streak. In comparison, low yields are obtained after a fall clean-up streak because no acid can be applied then without defeating the purpose of the clean-up streak. A chipper working on a rental basis would be more inclined to favor spring for the clean-up streak in view of the greater yields obtained.

Either of these methods will achieve the end objective of increased gum yields with the minimum of expended effort. The final choice of method rests with the producer, who knows which will best fit his own operating conditions.

Effects of Fertilizers on Yields

Some stands of turpentine pine yield more gum than others. One of the several factors responsible for this difference is nutrition. We have previously believed, but lacked proof, that better soil fertility conditions resulted in greater gum yields. Our belief has been substantiated by the experiment summarized in table 16 and figure 5.

Table 16.--Relative gum yields from slash pine trees in different yielding groups with and without fertilizer treatment

Treatment[1]	Yield level	Gum yield per crop[2]					Relative yield
		1946	1947	1948	1949	Average	
		Bbls.	Bbls.	Bbls.	Bbls.	Bbls.	Percent
Fertilized	High yielder	390.2	455.2	500.0	452.2	449.4	124
	Average yielder	377.4	427.3	509.1	519.5	458.3	126
	Low yielder	264.8	330.6	411.6	408.4	353.8	97
Not fertilized	High yielder	350.0	381.1	406.4	400.3	384.4	106
	Average yielder	318.6	352.8	400.7	382.6	363.7	100
	Low yielder	214.8	265.7	307.5	313.0	275.3	76
LSD bbls. per crop		137.6	190.5	197.0	192.4		

1/ All trees were bark chipped weekly and treated with sulfuric acid.
2/ Yield per crop of 10,000 faces.

The slash pine trees in this experiment were growing in an old field. They had large crowns and were not crowded. Before fertilizer was applied, all trees whose crown extensions were within 8 feet of the crowns of the experimental trees, were removed. A complete NPK fertilizer plus minor essential elements was applied three times each year at a total yearly rate of 500 pounds of nitrogen per acre. Our primary object was to demonstrate a possible effect, not delimit an optimum fertilizer treatment. Our secondary object was to determine whether trees of different yielding abilities responded the same to applied fertilizers.

The average yearly increase in gum yield due to fertilizer treatment was about 25 percent (significant at 5-percent level). This amount is substantial, and could well be worthwhile if the cost of fertilizer application was kept low. Determination of the correct amount of fertilizer that would prove practical will have to await results of future studies.

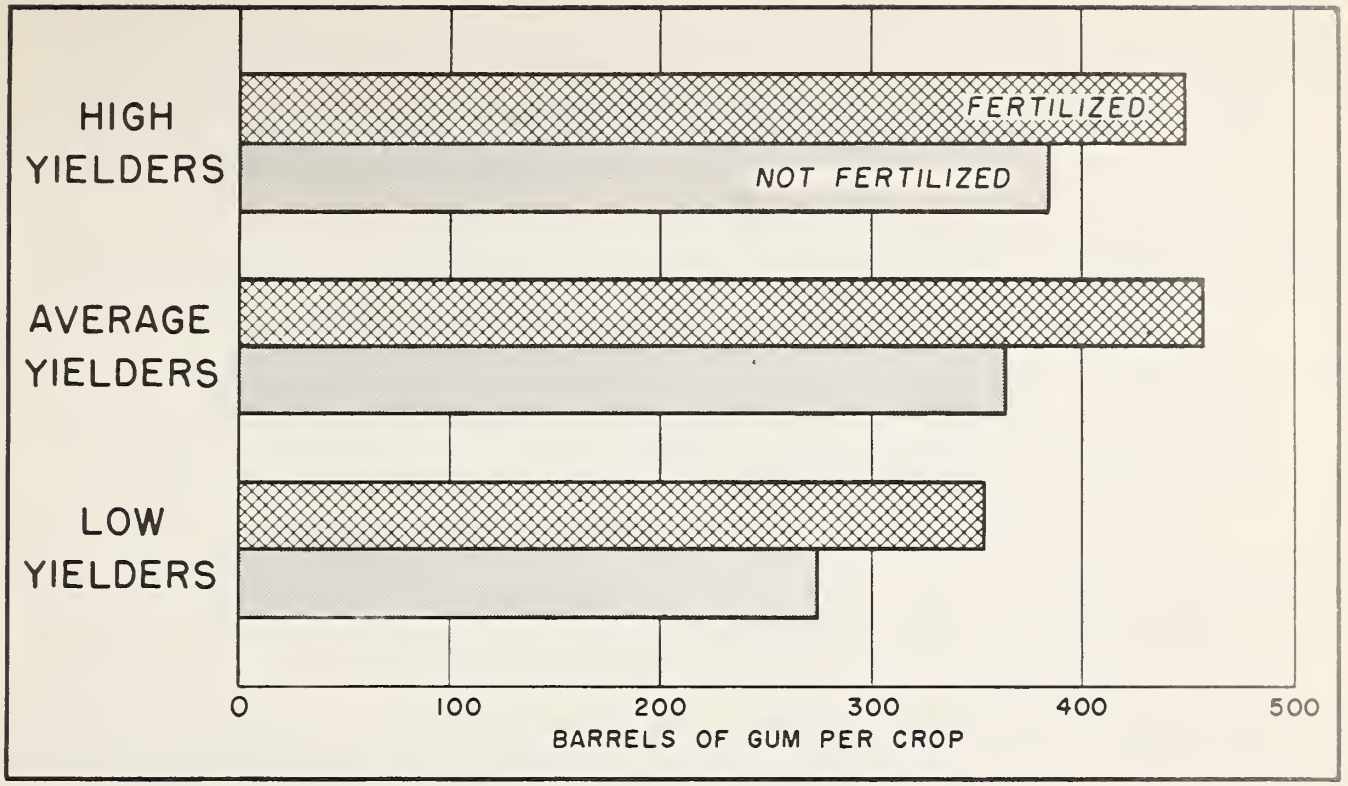

Figure 5.--Effect of fertilizing on gum yields from trees of different yielding abilities (average annual yield for 4 years of work).

Analysis of the total gum yields for the 4 years of turpentining revealed that the superiority of yields from the fertilized trees was statistically significant.

The high yields in this study, which were more than double those normally obtained, may be attributed to two factors. First, acid treatment was on a weekly basis, the most intensive that we use. Second, the trees all had large crowns, and all competing trees were removed from around each study tree.

It was expected that with the intensive treatment used, yields would decline after several years of work in the group with no fertilizer applied, while keeping relatively constant in the fertilized groups. This was not the case, since yields generally increased in both groups for the entire 4-year period. This may have been due to the fact that the trees were capable of this sustained high drain because of their excellent crowns and freedom from competition.

SUMMARY

Various modifications of potentially practical methods of turpentining, using bark chipping and acid treatment, have been studied at the Lake City, Florida, Research Center. The results of these studies for the past 5 years are given in this paper, and the relative merits of each method discussed. Briefly, some of the important conclusions of these studies from 1947 through 1951 are as follows:

1. Attaching tins on the surface of smoothed bark resulted in 12 and 35 percent more gum (slash and longleaf respectively), than when tins are inserted in the tree with a broadaxe. This result was obtained in trees bark-chipped and treated with acid, and confirms the same result obtained in earlier work with untreated deep chipping.

2. With weekly untreated deep chipping, gum yields increased with increase in tree diameter from 9.0 to 13.9 inches d.b.h. When trees were bark chipped and acid treated on a 2-week schedule, yields also increased with diameter, but the peak was apparently reached in the 12.0- to 12.9-inch class. It was also found that per inch of face width yields followed the same trend as mentioned above, with larger trees capable of yielding more gum per inch of face width.

3. The greatest relative yield increase due to acid treatment was noted in the lower-yielding groups of trees. The least response was found in the high-yielding groups, probably because they were already near their possible peak of sustained gum production.

4. For maximum gum production with good efficiency, a schedule of bark chipping and acid treatment every 2 weeks is best. A 3-week schedule is the most efficient chipping and treatment method, but the level of gum production falls to about that obtained with weekly untreated deep chipping.

5. A bark chipping height of 3/4 inch is best when a 3-week working schedule is used. For a 2-week schedule, a chipping height of 1/2 or 5/8 inch will give good yields and prolong the working life of the face, as well as reduce the final face height.

6. Face widths of 2/3 circumference are not practical. However, a face width of 1/2 the circumference will result in a 30-percent increase in yield over that from faces 1/3 circumference in width on average-size trees for a 2-year period. This latter method is recommended only where a single face is to be used just prior to harvesting the tree.

7. No more than two faces should be used simultaneously on a single tree. With weekly bark chipping and acid treatment, profitable yields were obtained from two-faced trees for 2 years in slash, and 3 years in longleaf pine. With a two-week chipping schedule, which is the general recommended procedure, it is doubtful whether two faces should be used on average-sized trees. With acid treatment the smallest tree that would profitably support two faces is probably about 13 inches d.b.h.

8. Split faces each 1/6 circumference in width and separated by a 2-inch bark-bar offer promise as a new turpentining method. Yield increases of 46 and 15 percent were obtained with split faces over a 2-year period for slash and longleaf respectively.

9. A sulfuric acid concentration of 50 percent proved best for both slash and longleaf over a 5-year period.

10. Preliminary tests indicated that a 2-percent 2,4-D solution resulted in yields equal to those obtained with sulfuric acid treatment when applied on slash pine. However, because low yields and excessive tree killing occurred when longleaf pines were treated with 2,4-D, this chemical is not recommended for general use.

11. Gum yields do not decline in successive years of work when trees are turpentined by bark chipping and acid treatment on a 2-week schedule. With weekly acid treatment, yields decline in succeeding years.

12. Sufficient evidence is not available to recommend winter work as standard practice when bark chipping and acid treatment is used. A 3-week winter schedule barely paid its way, resulted in reduced yields the next season, and was not efficient. To balance these drawbacks there were the advantages of a winter income and retention of labor force.

13. Spring is the favored time for a clean-up streak to remove acid-killed tissue, mainly because of greater yields obtained then, compared to negligible yields from an untreated clean-up streak in the fall.

14. Fertilizing trees definitely increases gum yields. Optimum fertilizer treatments have not yet been determined.

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